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Change in conductivity of CR-39 SSNTD due to particle irradiation

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Abstract : The electrical conductivity in gamma irradiated CR-39 SSNTD increase substantially compared to pristine samples On Si^{8+} irradiation in pristine samples the conductivity decreases below the resolution of the present measurement. When the gamma pre-irradiated samples are subjected to Si^{8+} irradiation (fluence = 5×10^9 to 5×10^{11} particles/cm^2) conductivity reveals an increasing tendency With the increase of Si^{8+} fluence, the conduction activation energy in these (γ+ Si^{8+}) exposed samples changes towards the activation energy of the only γ irradiated samples These results are explained on the basis of dipolar orientation of the polymer chains.

Keywords : SSNTD, CR-39 polymer, electrical conductivity

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1. Introduction

CR-39 (allyl diglucol carbonate) is a polymeric track detector used in different fields of nuclear radiation detection for its high sensitivity. Various efforts have been made to study its track formation mechanism so as to exploit its full potentialities for a sensitive track detector in diverse fields of applications. From the ion explosion spike model [1] it is suggested that the physical parameters like carrier density and mobility, dielectric constant *etc* of a material are mainly responsible for its track recording character. It has also been reported that gamma-irradiation can be used in polymeric materials to change or modify the near surface characteristics of a bulk polymer [2]. So an investigation has been carried out to study the changes in conductivity in CR-39 SSNTD due to Si^{8+} irradiation in pristine CR-39 and pre-exposed 50-gray gamma- irradiated samples.

2. Experimental details

CR-39 (Pershore Mouldings Ltd. U.K.) sheets of 250 μm thickness were cut in the dimension 0.9 cm × 0.9 cm. These samples were chemically cleaned properly and allowed to dry in room-temperature. The cleaned samples were exposed to gamma irradiation of 50 gray dose. This was done with the help of a phoenix telecobalt unit*. The average energy of the gamma-rays was 1.25 MeV. The irradiation was carried out at room temperature. These samples were then exposed to 100 MeV Si^{8+} radiation in the material science scattering chamber of the 15 UD Pelletron at Nuclear Science Centre, New-Delhi.** The fluences used ranged from 5×10^9 cm^{-2} to 10^{12} cm^{-2}. Beam size was adjusted to 1 cm × 1 cm and the pressure during irradiation was $\sim 3 \times 10^{-6}$ torr. The temperature during irradiation was maintained at 85 ± 2 K with the help of a LN_2 cold-finger arrangement.

The resistivity of the samples was measured by an high impedance (10^{14} Ω or higher) ECIL electrometer amplifier. Ag electrodes of dimension 0.3 cm × 0.5 cm were vacuum evaporated on the two sides of CR-39 samples with the help of a conventional Hindhivac coating unit. As a result an Ag-CR-39-Ag sandwich type cell structure was obtained. The experimental sample assembly connected with electrical and thermocouple leads was kept inside A B-34 ground-glass jacket with the provision of continuos evacuation through a stop-cocked side-tube. The experimental observations were carried out inside a Faraday cage to avoid external noise and pick-up.

3. Results and discussion

Figure 1 depicts the I–V characteristics of the samples. There is no deviation from linearity and hence the conductivity processes involved must be of bulk conductivity type and not of

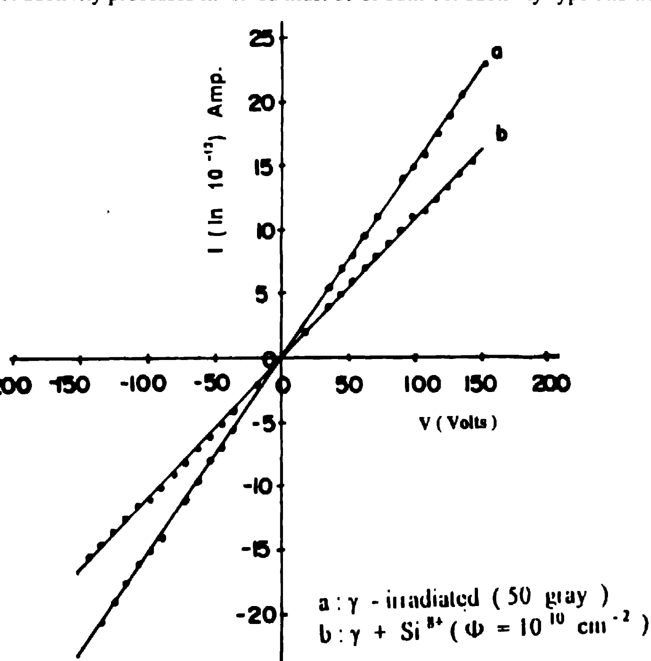

Figure 1. I *vs* V curves of CR-39 at different conditions (Dots - experimental points) (Line - fitted curves)

due to the electrode contact controlled type. It may be noted that the current increased with the increase of temperature for the same applied voltage in both the pristine and irradiated states. In the present study, the samples are polymer dielectric materials and thus have the possibility for dipolar orientation. Increase in conductivity in case of gamma-irradiated can be attributed to the fact that the dipolar orientation due to the applied field is reduced [3].

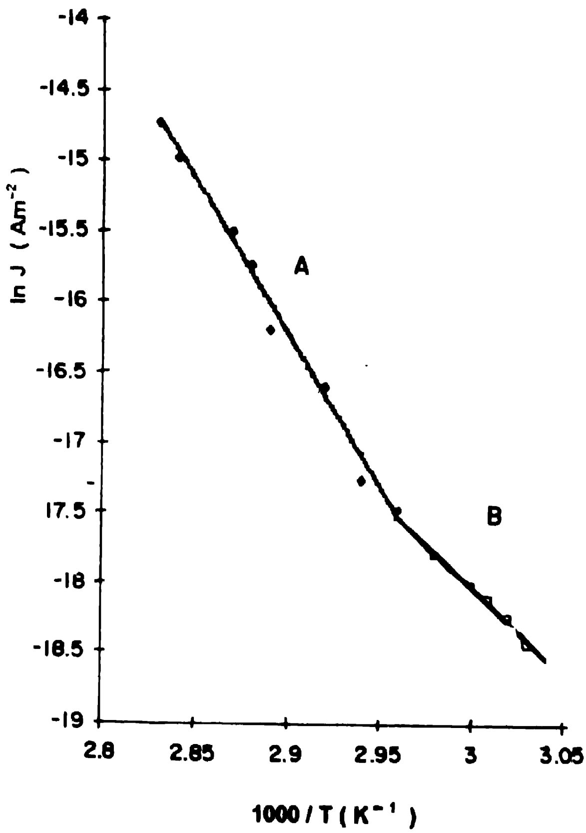

Figure 2. ln J (Am^{-2}) *vs* 1000/T(K^{-1}) for pristine CR-39. (Dots - experimental points) (Line - fitted curves).

The temperature dependence of conductivity is depicted in Figure 2 and Figure 3 for pristine and irradiated samples respectively. The activation energies have been calculated from these plots. It is observed that in the fresh sample there two regions of activation energies while in the irradiated samples there are three activation regions. It may be noted that the conductions in region A and B are due to carrier excitation to unlocalised and localised states respectively. Region C may be attributed to carrier hopping transport. If the density of defect states is high, then process B will not dominate in any temperature range and a direct transition from A to C will result which is the case of the pristine sample [4].

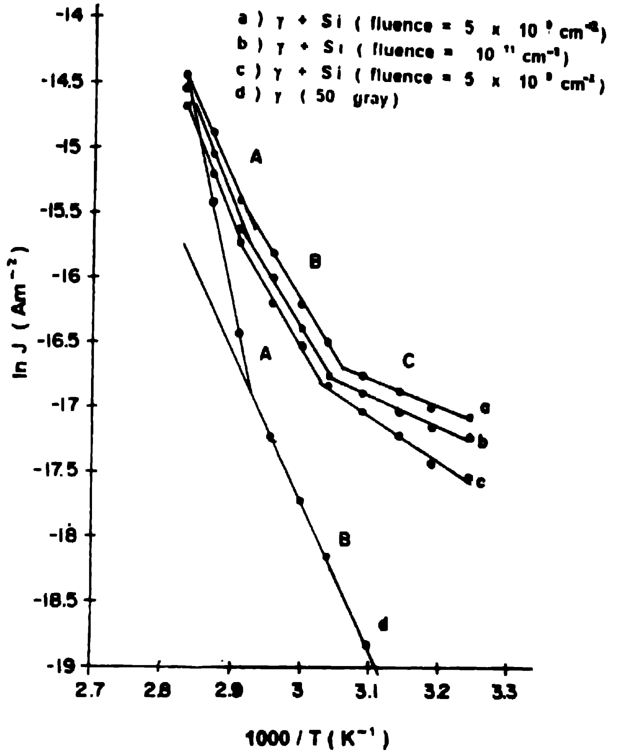

Figure 3. ln J (Am^{-2}) *vs* 1000/T(K^{-1}) graphs of irradiated CR-39. (Dots - experimental points) (Line - fitted curves).

The corresponding computer fit equations in each region are also given in the figures. The activation energies are given in Table 1. From these data it may be noted that the activation

Table 1. Activation energies for fresh and irradiated samples.

Sample type	Activation (region A)	Energies (region B)	(region C)
Pristine	1.02 eV	1.76 eV	
Gamma (50 gray) irradiated	2.05 eV	0.936 eV	
Gamma (50 gray) and Si (5 x 10^9)	0.964 eV	0.684 eV	0.171 eV
Gamma (50 gray) and Si (10^{11})	1.01 eV	0.688 eV	0.192 eV
Gamma (50 gray) and Si (5 x 10^{11})	1.05 eV	0.724 eV	0.284 eV

energies decrease in general in irradiated samples compared to fresh samples. For values of activation energy lower than 0.2 eV, the conduction may be due to an electronic mechanism and for values more than 0.6 eV it could be either electronic or ionic [5]. From the observed values of activation energies it is seen that the conduction may be electronic or ionic in nature.

Acknowledgments

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References

[1] R L Fleischer, P B Price and R M Walker *Nuclear Tracks in Solids : Principles and Applications* (Berkeley : University of California Press) (1976)

[2] L Calcagno, G Compagini and G Foti *Structural Modification of Polymer Film by Ion Irradiation. Nucl. Inst. and Meths. in Physics Research* **B65** 413 (1992)

[3] M El Shahawy, A Hussein and A Tawansi *CR-39 as a Gamma Dosimeter : Dielectric and Infrared Studies, Journal of Material Sc.* **27** 6605 (1992)

[4] N F Mott and E A Davis *Electronic Processes in Non-crystalline Materials* (Oxford : Clarendon Press) (1971)

[5] B Bhattacharjee, H L Das and T D Goswami *DC Conductivity of Cellulose Nitrate Particle Track Detector, Radiation Measurements* **Vol. 23** (No. 1) p 231 (1994)